FAA-E-2579
October 29, 1973

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

TRANSCEIVERS UHF 225 - 400 MHz

1. SCOPE AND CLASSIFICATION

1.1 Scope.- The equipment covered by this specification are 3-watt minimum, solid-state, pretuned, multi-channel amplitude modulated UHF transceivers capable of operating on any channel in the band 225 - 400 MHz in a 50 kHz channel spacing environment. These transceivers will be used for emergency communications at FAA facilities.

2. APPLICABLE DOCUMENTS

2.1 FAA specifications.- The following FAA specifications of the issues specified in the invitation for bids or requests for proposals, form a part of this specification:

FAA-D-2494/1 and 2494/2	Instruction Books, Equipment and Systems
FAA-G-2100/1b	Electronic Equipment, General Requirements Part 1, General Requirements for all Equipments
FAA-G-2100/3a	Part 3, Requirements for Equipments Employing Semiconductor Devices
FAA-G-2100/4b	Part 4, Requirements for Equipments Employing Printed Wiring Techniques
FAA-G-2100/5	Part 5, Requirements for Equipments Employing Micro-electronic Devices

FAA-STD-013 Quality Control Program Requirements

(Copies of this specification and of the applicable FAA specifications and drawings, may be obtained from Federal Aviation Administration, Washington, D. C. 20591, ATTN: Contracting Officer. Requests should fully identify material desired, i.e., specification numbers, dates, amendment numbers, complete drawing numbers; also requests should state the contract involved or other use to be made of the requested material.)

2.2 Military documents.-

MIL-C-3098le Crystal Units, Quartz, General Specification of

(Information on obtaining copies of Military publications is given in the SUPPLEMENT-4 of FAA Specification FAA-G-2100).

3. REQUIREMENTS

3.1 Equipment to be furnished by the contractor.- Each transceiver furnished by the contractor shall be complete in accordance with all specification requirements. Instruction booklets shall be furnished in accordance with FAA-D-2494/1 and /2.

3.1.1 Crystals for testing.- The contractor shall furnish for his own use all channel crystals (3.4.4.3) necessary for testing the equipment covered by this specification (channel crystals shall not be furnished with the equipment).

3.1.2 Non-channeling crystals.- Non-channeling crystals (3.4.4.2) shall be furnished with this equipment.

3.2 Service conditions.- The ambient conditions shall be those of Environment I (1-3.2.23, FAA-G-2100/1b).

3.2.2 Power source, battery charger.- The battery charger (3.8.5) shall operate from a single-phase 120 V 60 Hz (design-center values) AC line power source.

3.2.3 Power source, transceiver.- The transceiver shall operate from a DC power source having a design-center value of 12 V, a normal test condition tolerance of $\pm$ 1 V, and a service condition range of 10 V to 14 V (modifies 1-3.2.21 to 1-3.2.23 of FAA-G-2100/1b).

3.3 General functional requirements.- The transceivers specified herein shall consist of a 3-watt minimum, 3-channel minimum, pretuned, amplitude modulated transceiver (1.1), powered by an internal and external source of 12 V DC. The channels shall be capable of being tuned in any combination to all frequencies in the band 225 - 400 MHz. The unit shall be made capable of portable operation.

3.3.1 Solid-state design.- The use of semiconductors instead of electron tubes is required for all circuit applications.

3.4 General construction requirements

3.4.1 Finish.- The transceiver case shall be finished in accordance with 1-3.8.2 of FAA-G-2100/1b.

3.4.2 Nameplate.- The nameplate furnished in accordance with 1-3.13 of FAA-G-2100/1b shall be mounted on the front panel. The following title shall be used:

UHF TRANSCEIVER 225 - 400 MHz

3.4.3 Marking methods.- In modification of FAA-G-2100/1b, exterior and interior markings shall be in accordance with 1-3.12.7 of FAA-G-2100/1b. except that item (d), stenciling, shall not be used on the front panel.

3.4.4 Design.

3.4.4.1 Power drain.- The maximum allowable power drains are as follows:

(a)	Transmit	25 watts
(b)	Receive	9 watts
(c)	Standby	5 watts

3.4.4.2 Non-channeling crystals.- All non-channeling crystals shall be designed and manufactured to meet the requirements of MIL-C-3098(e).

3.4.4.3 Channel determining crystals.- All channel determining oscillators shall meet all applicable specifications when utilizing CR-98/U type crystals.

3.4.4.4 Tuning.- Each tuning control shall be capable of being adjusted on either side of the tuning point. The tuning point should fall within the center two thirds of the adjustment range. Values of adjustable elements should be chosen to preclude false or multiple tuning points. Continuous tuning adjustment shall be provided without changing coils, taps or links.

External test equipment shall not be required to establish proper operation when switching between any of the pretuned channels.

3.5 Transceiver equipment construction.- The complete transceiver shall be contained in a case (3.8) fabricated of sheet aluminum. The rear enclosure shall be fabricated of aluminum screening or perforated plate to provide ventilation and protection from insertion of foreign objects. The weight of the unit, including all accessories, shall not exceed 40 lbs. The case dimensions inclusive of the cover/s shall be such that the maximum dimensions shall not exceed 16 inches in depth or length nor 8 inches in height.

3.5.1 Front panel layout.- The front panel shall contain as a minimum a power switch, channel selector, card holder, squelch control, receiver audio control, headphone jack and receptacle for microphone.

3.5.1.1 Power switch.- One toggle switch shall be provided for controlling the DC power input to the equipment.

3.5.1.2 Fusing.- The positive side of the DC input shall be fused with AGC size fuses. Fuse holders shall be Bussmann Manufacturing Company, Type HKP, or equal.

3.5.1.3 Channel selector.- A means shall be provided for rapid and positive selection of any of the three preset channels. The transceiver shall transmit and receive on the same frequency for each position of the channel selector, and switching between any of the three channels shall require no further adjustment of the equipment other than readjustment of the antenna length.

3.5.1.4 Card holder.- A card holder with card to indicate the frequency of the three assigned channels shall be provided.

3.5.2 External connections.- The rear of the equipment shall contain a DC power connector, AC power connector and an RF connector, (UG 58A/U or equivalent). Mating connectors shall be provided.

3.5.3 Circuit components.- MIL Spec relays are not a requirement, modifies FAA-G-2100/1b. Relays may be of the plug-in type. All plug-in type relays shall be provided with a clamping device.

3.5.4 Common circuitry.- Transmission and reception shall be nonsimultaneous; therefore, common circuitry between "transmit" and "receive" positions of the transceiver may be used.

3.5.5 Protection.- A method shall be incorporated to protect the equipment from any damage if the polarity of the power source is reversed, and if the antenna is removed or transmission circuit becomes open or shorted.

3.5.6 Adjustment.- Removal of access covers or plates if required to obtain access to tuning controls shall be accomplished by using standard locally available tools. If the case must be removed to permit circuit adjustments, its replacement shall not affect the adjusted circuits nor require offset adjustment as compensation for case replacement. All alignment tools required for making circuit adjustments shall be supplied with each transceiver and attachment clips provided inside the case for storage.

3.5.7 Servicing facilities.- Test jacks shall be provided and connected as described in the subparagraphs below. In addition, not less than one ground pin-jack (black) and one +12 V DC pin-jack (red) shall be furnished.

3.5.7.1 AVC pin-jack.- A pin-jack (green) shall be connected to the AVC bus through an isolating resistor for use when aligning circuits.

3.5.7.2 Headphone jack.- A telephone jack for .250 inch plug shall be mounted on the transceiver front panel. The power output level at the telephone jack, when terminated in a 2,000 ohm resistive load, shall be

between 20 to 25 dB below that at the output terminals when terminated in a resistive load equal to the nominal speaker impedance. When connecting headphone, provisions shall be made to disconnect speaker.

3.5.7.3 Carrier level and modulation monitor pin-jack.- A pin-jack (white) shall be connected through an isolation resistor of not less than 47 k ohm to the output of a circuit which samples and rectifies the RF output of the transmitter. The sampling circuit shall provide a DC voltage suitable for measuring on a Triplett Model 630 VOM or equal. It shall also provide a means of viewing the RF envelope on an oscilloscope.

3.6 Receiver Section.

3.6.1 Frequency range.- The UHF receiver shall be capable of being pretuned to any three frequencies within the range of 225.000 to 400 MHz.

3.6.2 Tuning procedure.- The following initial conditions shall apply to all frequency accuracy and stability requirements herein. The equipment shall be tuned under the normal test conditions, using the procedures as given in the instruction book. No frequency measuring equipment shall be required in the initial tune-up. After this initial tune-up no further adjustments shall be made to controls unless specifically allowed hereinafter. Normal test conditions under ambient temperature and humidity, and line voltage, shall apply to each subparagraph hereunder except where specifically stated otherwise.

3.6.2.2 Initial accuracy.- The operating frequency of each equipment as aligned on its assigned frequency shall be within $\pm$0.00175 percent of that frequency.

3.6.2.3 Crystal oscillator stability.- Under the range of service conditions, the receiver shall incorporate a crystal oscillator possessing inherent stability characteristics sufficient to achieve a frequency accuracy within $\pm$0.002 percent of the operating frequency of the receiver.

3.6.3 RF input circuit.- The RF input of the receiver shall be designed to match a nominal 50 ohm unbalanced transmission line.

3.6.4 RF sensitivity.- An RF input voltage of 5.0 uV modulated 30 percent with 1,000 Hz shall produce an audio output of one watt into a resistive load with a signal-plus-noise-to-noise ratio of not less than 10 dB under normal test conditions and not less than 5 dB under service conditions. The noise voltage shall be measured with the RF input voltage applied without modulation and with the squelch control adjusted for maximum sensitivity. The resistive load shall be equal to the impedance of the speaker circuit. (Referred to hereafter throughout the specification as "resistive load.")

3.6.4.1 Desensitization due to strong RF signals.- With an RF input voltage of 5.0 uV (see 4.1.1) modulated 30 percent with 1,000 Hz producing 0.1 watt into the resistive load, the following high-level, off resonance (off channel), unmodulated signals (undesired) shall not reduce the receiver output more than 8 dB.

Undesired Level Volts	± MHz Off Resonance
0.025	1.5
0.075	3.0
0.250	6.0
0.750	9.0

3.6.4.2 Cross modulation.- With the receiver's audio gain control set so that an RF input voltage of 5.0 uV (see 4.1.1) modulated 30 percent with 1,000 Hz produces one watt into a resistive load the simultaneous application of 90 percent modulated off resonant signals (undesired) of the frequency and level given in Paragraph 3.6.4.1 and unmodulated on resonance signals whose level varies over the range of 5.0 uV to 10,000 uV shall not produce an output exceeding 0.150 watts into a resistive load.

3.6.4.3 RF intermodulation.- With the receiver gain control set so that an input voltage of 5.0 uV at resonance (f_o) modulated 30 percent with 1,000 Hz will produce 1.0 watt into a resistive load, the simultaneous application of two off-resonant signals f_a and f_b of not less than 1,000 uV each in place of the 5 uV resonant frequency signal, shall be required to produce an audio output of 0.25 watts. The two off-resonant signals shall be spaced 100 kHz from each other and f_a ±100 kHz from f_o and so related that $f_o = 2 f_a - f_b$. The carrier amplitude of the two off-resonant signals shall be equal to each other. Signal f_a shall be unmodulated and signal f_b shall be modulated 30 percent at 1,000 Hz.

3.6.5 Selectivity.- The bandwidth of the intermediate frequency amplifier for 50 kHz channel spacing shall conform to the following profile with respect to the center frequency.

Attenuation	Bandwidth
6 dB	±18 kHz minimum
20 dB	±27 kHz maximum
40 dB	±31 kHz maximum
60 dB	±35 kHz maximum
80 dB	±40 kHz maximum

3.6.5.1 Pass band characteristics.- Any decrease in the pass band envelope (±15 kHz) shall not exceed 1 dB below the peaks of the envelope.

3.6.6 Image and IF rejection.- For any frequency from 400 kHz to 800 MHz with the exception of frequencies within the 80 dB selectivity bandwidth the image and IF rejection shall be not less than 60 dB.

3.6.7 Audio output circuit.- The receiver shall have at least one pair of audio output terminals that are connected to the speaker (3.8.2). This output shall be in addition to the output listed in 3.5.7.2. No DC voltages shall appear at the audio output terminals.

3.6.8 Audio gain control.- An audio gain control (audio taper) shall be provided on the front panel. The full rated output shall be obtained with the audio gain control set at or below the maximum clockwise position. Rotation of the audio gain control in a counter clockwise direction shall result in a smooth reduction of output from maximum to minus 10 dBm or less.

3.6.9 Rated audio output.- The full rated output of the receiver shall be not less than 1 watt into the resistive load with an input signal of 10 uV modulated with 1,000 cycles per second at 30 percent modulation.

3.6.10 Audio frequency response.- With the constant RF input voltage of 50 microvolts, modulated 30 percent by each audio frequency, the audio output voltage measured across the resistive load shall vary as listed in the following tabulation from a 0.5 watt reference audio output voltage obtained at 1,000 Hz.

(a)	Below 300 Hz	Decrease continuously as frequency decreases
(b)	300 - 3,000 Hz	Total variation shall not exceed 6 dB
(c)	Above 3,000 Hz	Decrease continuously as frequency increases

3.6.11 Distortion.

3.6.11.1 Harmonic distortion.- With an RF input voltage of 100 microvolts, modulated at 90 percent with 1,000 Hz and the audio gain control adjusted for full rated power output across a resistive load, the total harmonic distortion shall not exceed 20 percent.

3.6.11.2 Hum and noise distortion.- With RF input voltages of 300 uV to 100 millivolts, modulated at 30 percent with 1,000 Hz applied to the receiver input and with 0.12 volts RMS 120 Hz ripple on the 12 V DC input, the hum and all other extraneous signals including hum modulation of the 1,000 Hz tone delivered to an audio output resistive load shall not exceed a level which is 30 dB below the output level of the 1,000 Hz tone over a range of outputs from 0 dBm to +30 dBm.

3.6.12 Automatic volume control.- The receiver shall have an automatic volume control circuit which will maintain an output voltage that will not vary more than 6 dB when the RF input voltage in the frequency range specified in 3.6.1 is varied from 10 microvolts to 100 millivolts, modulated 30 percent with 1,000 Hz.

3.6.13 Squelch.- A carrier-operated anti-noise circuit shall be provided. The ghreshold shall be adjustable over the RF input voltage range of 0 to 100 microvolts (3.5.1 and 4.1.1).

3.6.14 Stability of operation.- The receiver shall be free from microphonic tendencies and all traces of regeneration which may appear as squealing, whistling, or motorboating for all combinations of control settings, for all values of signal modulation from 0 to 90 percent and for RF input voltages up to 0.1 volt under normal operating conditions.

3.6.15 Oscillator coupled output.- Oscillator, oscillator harmonics and all other spurious outputs shall not exceed 20 microvolts as measured at the antenna receptacle terminated into 50 ohms.

3.6.15.1 Oscillator interaction.- Sufficient isolation and shielding shall be incorporated, to insure that all outputs due to heterodyning do not exceed a level which is 10 dB below the output produced by a standard RF input tests voltage of 5.0 uV, and to insure that the squelch does not open due to such heterodyning.

3.7 Transmitter section.- The transmitter portion of the transceiver shall be capable of transmitting on any one of three pretuned channels. Each of the three channels shall meet all the specification requirements.

3.7.1 Frequency range.- The UHF transmitter shall be capable of being tuned to any three frequencies within the range of 225.00 to 400 MHz.

3.7.2 Carrier frequency accuracy and stability.

3.7.2.1 Tuning procedure.- The following initial conditions shall apply to all frequency accuracy and stability requirements herein: The equipment shall be tuned under the normal test conditions, using the procedures as given in the instruction book, with a crystal which meets specification requirements applicable thereto. No frequency measuring equipment shall be required in this initial tune-up. After this initial tune-up, no further adjustments shall be made to controls unless specifically allowed hereinafter. Normal test conditions under ambient temperature and humidity, and line voltage, shall apply to each subparagraph hereunder except where specifically stated otherwise.

3.7.2.2 Initial accuracy.- The output frequency of each equipment as aligned on its assigned frequency shall be within $\pm$0.00175 percent of that frequency.

3.7.2.3 Stability.- The output frequency of each equipment shall be within $\pm$0.002 percent of the assigned frequency under the range of service conditions and at all percentages of modulation up to the maximum specified herein.

3.7.3 Rated carrier power output.- Under normal test conditions, the unmodulated carrier power output shall be not less than 3 watts into a 50 ohm load.

3.7.3.1 Power output stability under service conditions.- With the transmitter initially adjusted for rated power output under normal test conditions except with the DC line voltage constant at 12 volts, the power output shall not vary more than 10 percent under the service conditions (power variation from Step 3 through Step 6 of Paragraph 1-4.12 FAA-G-2100/1b.)

3.7.3.2 Carrier amplitude stability under modulation.- At rated output, the carrier power amplitude shall not vary more than 10 percent when modulated up to 90 percent by an audio frequency of 1,000 Hz.

3.7.4 Modulation.

3.7.4.1 Type of modulation.- The carrier shall be amplitude modulated by an external voice source, i.e., emission A3.

3.7.4.2 Percentage of modulation.- The carrier shall be capable of being modulated 90 percent. The modulator shall meet this requirement at all audio frequencies in the range of 300 to 3,000 Hz.

3.7.4.3 Modulation level and limiting.- The modulation level shall be adjustable from below 30 percent up to 90 percent at 1,000 Hz. A method (e.g., speech clipping) shall be provided to prevent the modulation level from exceeding 100 percent when the input level is increased up to 15 dB over the 90 percent modulation level. No evidence of splatter should be detectable.

3.7.4.4 Frequency response.- With a constant input amplitude the frequency response shall be in accordance with the following at all percentages of modulation up to 90 percent. Throughout the range of 300 to 3,000 Hz the modulation amplitude shall not vary more than 3 dB and below 300 Hz and above 3,000 Hz the modulation amplitude shall decrease continuously as the frequency is decreased and increased respectively. The modulation amplitude at 10,000 Hz shall be down not less than 20 dB compared to the modulation amplitude at 3,000 Hz.

3.7.4.5 Harmonic distortion.- With the full rated RF output (3.7.3) modulated at each frequency within the audio range of 300 to 3,000 Hz, the total harmonic distortion in the demodulated carrier shall not exceed the percentages given in the following tabulation:

Frequency	Modulation	Distortion
300 to 3,000 Hz	30%	7.5%
300 to 3,000 Hz	90%	10%

3.7.5 Spurious output.- At rated power output, the level of all spurious outputs shall not exceed a level of 60 dB below the level of the carrier fundamental when measured at the output of the transmitter terminated in an unbalanced 50 ohm resistive load over the frequency range of 6 MHz to 1,000 MHz.

3.7.5.1 Carrier noise.- At rated power output the amplitude of the carrier noise shall not exceed a value corresponding to 50 dB below 90 percent modulation.

3.7.6 Audio inputs.- An audio input connector shall be provided for mating with the microphone 3.8.2.

3.7.7 Push-to-talk circuitry.- Provision shall be made for placing the transceiver in the "transmit" condition within 75 ms after closing the keying contacts, for placing the transceiver in the "receive" condition within 100 ms after opening the same external contacts. The above conditions shall exist with an external keying circuit having a resistance of 0 to 300 ohms.

3.8 Case.- The equipment case shall provide for transporting and stowing the transceiver, antenna, microphone, speaker, battery, battery charger, AC power cord. The case shall be aluminum (3/32 inch minimum) having the finish as specified in 3.4.1. A sturdy metal handle by which the case can be lifted shall be provided. The interior of the case shall be divided into compartments such that the transceiver is placed separate from the appurtences, and all components are secure and unable to shift. The case shall incorporate cover/s such that the compartments are easily accessible when the case is in its normal position. Latches shall be provided to secure the cover/s in the closed position. The covers in the closed position shall provide protection for all panel controls and equipment connectors.

3.8.1 Microphone.- A hand held, noise-canceling, microphone with a ceramic element shall be provided. This microphone shall have a built-in press-to-talk switch and a tinsel type coiled cord a minimum of five feet in length extended. The cord shall be terminated with a locking connector for plugging into a receptable mounted on the front panel. The microphone provided shall meet the following requirements:

(a) Sensitivity: Output not less than -55 dB, (0 dB = 1 volt) into high impedance with 10 microbars at input.

(b) Frequency response: Output level shall not vary more than 8 dB over the range of 300 to 3,000 Hz.

(c) Signal-plus-noise-to-noise ratio: This ration shall be not less than 30 dB.

(d) The microphone case shall be made of hard impact plastic.

The manufacturer of the microphone shall provide a certified statement verifying that the microphone meets the above requirements.

3.8.2 Speaker.- A loudspeaker, three-inch size or greater, shall be built into the case. The speaker shall be capable of continuously handling the rated one watt output of the receiver without rattling or blasting.

3.8.3 Antenna.- A quarter wave whip antenna for 225 MHz (maximum length) shall be provided. The whip shall be adjustable to cover the range of 225 MHz to 400 MHz and shall make positive contact when set to any assigned frequency and shall be utilized for both transmission and reception. The antenna shall be marked to show correct length for operating on 225, 250, 275, 300, 325, 350, 375 and 400 MHz.

3.8.3.1 Antenna connections.- A means shall be provided inside the case for securing the base of the antenna while in its operating position. Provisions shall also be provided for connecting an external antenna by means of RF cable and connector.

3.8.4 Battery.- A 12 volt sealed rechargeable battery of sufficient capacity to operate the transceiver within the specification requirements for not less than four hours on a duty cycle of 10 percent transmit, 10 percent receive, and 80 percent standby shall be provided.

The battery shall be capable of retaining 90 percent of its capacity after undergoing at least 100 four-hour operations of the transceiver with the battery being recharged each time by the charger (3.8.5). The battery shall be capable of being stored and operated in any position.

3.8.5 Battery charger.- A battery charger shall be provided which will fully charge the battery within 12 hours after the 4-hour discharge. The battery charger shall be incorporated within the transceiver. In addition, the charger shall be capable of providing sufficient filtered power to permit operation of the transceiver to meet all specification requirements with the battery recharging in the circuit with the duty cycle of 3.8.4. The battery being recharged shall not be damaged when the charger is left on for extended periods. Fusing shall be accomplished per Paragraph 1-3.7.3 and 1-3.7.3.1 of FAA-G-2100/1b.

3.8.6 AC power cord.- A detachable power cord shall be provided for operation of the battery charger. The cord shall be three-conductor, stranded, rubber or plastic jacketed, no less than six feet long, terminated with a grounding type rubber finger-grip cap. See 1-3.6.6 of FAA-G-2100/1b. Space shall be provided for storage of the power cord within the carrying case when the unit is being transported.

3.8.7 Interconnection.- The transceiver shall be capable of being operated in the case with only the cover/s open and the microphone and antenna connected. The AC power cord shall be so arranged that the battery can be left on charge when the unit is stored.

4. QUALITY ASSURANCE PROVISIONS

4.1 General.- See Section 1-4 of FAA-G-2100/1b for classification of tests and general methods of sampling and inspection. The contractor shall provide and maintain a quality control program which meets the requirements of FAA-STD-013.

4.1.1 Receiver input test voltages.- All tests which require a signal to be applied to the RF input of the receiver shall be connected with a symmetrical 50 $\pm$2 ohm 6 dB pad inserted between the signal source and the receiver input. All applicable voltages given in this specification shall be measured across the input of this pad.

4.1.2 Antenna loading tests.- With the whip antenna secured in its operating position (3.8.3), the contractor shall demonstrate that the transmitter can be tuned and the antenna adjusted so that the incident power is not less than 3 watts and the reflected power not more than 10 percent of the incident power.

5. PREPARATION FOR DELIVERY

5.1 General.- See Section 1-5 of FAA-G-2100/1b Level "C".

6. NOTES.

6.1 NONE.

* * * * *

INDEX